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STEVENSON (CALIF.) EXPERIMENTAL ARCH DAM

Extensive tests upon the dam at Stevenson Creek, Fresno County, Calif., described in Technical News Bulletin No. 110, June, 1926, have been completed according to the present program. Complete sets of deformation, strain, and slide measurements have been made for varied loads up to those produced by a head of 60 feet, the height of the crest of the dam. The tests upon the dam have been made at night to eliminate temperature effects as far as possible.

The only signs of failure are two vertical cracks in the center line of the dam, one extending from the lowest point upward some 13 feet, the other from the highest point downward some 19 feet. The top crack opens widest at a head of 45 to 50 feet and at a head of 60 feet returns practically to the same width as when no water is in the reservoir. This crack does not permit water to seep through. Its maximum width is about 0.03 inch, and the lower crack is still smaller.

Cracks formed at the abutment between the dam and the foundation rock a short time after the completion of the dam, presumably because of shrinkage or temperature changes. These cracks were covered with a fillet of mortar in order to facilitate their observation. Very little change has occurred in them.

The work of analyzing the data is now sufficiently advanced to warrant the following conclusions:

1. The load carried due to the horizontal thrust in the horizontal elements (the arch ribs) has been determined for all parts of the dam under the 60-foot head. The load is a maximum about the mid height and decreases to a small amount both at the top and bottom of the dam.

2. The load carried by bending of the horizontal elements has been approximately determined at certain places. The indication is that the greater part of the load lies nearer the vertical center line of the dam.

3. The load carried by the bending of the vertical elements has been partially determined. Evidently near the bottom of the dam practically all of the load is carried in this manner. Near the top none of it seems to be so carried, and the vertical elements appear to be supported by the horizontal elements.

A study of the advisability and nature of further tests upon the dam and of increasing the height of the dam is now being made by the engineers in charge.

PLASTICIMETER BASE PLATES

The Emley plasticimeter, developed at the bureau, affords a convenient method for measuring the plasticity of lime. In using this instrument a specimen of lime putty is placed on an absorptive base plate, the plate and specimen then being turned at a uniform rate and raised against a smooth steel plate. The base plate corresponds to the scratch and brown coats of plaster and the steel plate to the plasterer's trowel. The torque which the specimen exerts on the steel plate and the time elapsing between the beginning of the test and the development of the maximum torque are measured. These two quantities are used to calculate the "plasticity figure" of the lime.

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When determinations of the "plasticity figure" made at the bureau did not check with those made on the same lime at the plant, an inquiry into the possible causes of the discrepancy was made. The uniformity of the base plates was the first matter to be considered, and the results obtained indicate that therein lies the possibility of much inconsistency. The only requirement at present demanded of the plates is that they absorb between 20 and 25 per cent of their weight of water when immersed for two hours. Although this requirement is met by all the plates which have been tested, the rate of absorption differs markedly. There are distinct types of plates, the rate of absorption of those of the same type being almost identical, while there is great variance among different types. As a specific example, plates of one type absorbed as much water in 4 minutes as those of another type absorbed in 80 minutes, the absorption being expressed as per cent of the weight of the plate. It follows that the time required for the specimen to exert its maximum torque would be much less with plates of the former type and the resulting "plasticity figure" much lower than with plates of the latter type.

The minor amount of work completed indicates that further consideration should be given to the specifications for the base plates with regard to embodying a "rate of absorption" requirement, and it is proposed to make such a recommendation to the lime committees of the American Society for Testing Materials and the Federal Specifications Board.

THERMAL EXPANSION OF CLAYS AND SPECIAL REFRACTORIES

As a preliminary phase of a proposed comprehensive study of the fundamental characteristics of so-called "special refractories," representative fire-clay refractories and the individual clays used in their manufacture, the bureau has completed a number of observations of thermal expansion from room temperature to approximately 1,000° C.

The materials investigated include foreign and domestic magnesite; diaspore; bauxite; samples of Indian, Grecian, African, Turkish, and Cuban chrome ore; alumina; artificial corundum; cyanite; silicon carbide; zirconium silicate; specimens of 13 brands of fire brick from the principal producing districts of the country; three brands of commercial silica brick; and specimens of foreign and domestic kaolin and ball clay.

The thermal expansion of the foreign and domestic magnesite is practically the same, averaging about 1 per cent from room temperature to 850° C. The expansion of the bauxite is somewhat higher than that of the diaspore above 500° C., the observations showing about 0.70 and 0.53 per cent expansion, respectively, from room temperature to 900° C. All of the chrome ores tested showed roughly the same expansion characteristics; the rate was practically constant from room temperature to 1,000° C.; and the total expansion varied from 0.70 to 0.85 per cent.

The specimens of calcined alumina plus 10 per cent English china clay, artificial corundum, cyanite, silicon carbide, and zirconium silicate were burned to cone 16 prior to testing.

The specimen of clay-bonded alumina showed a somewhat higher expansion at 1,000° C. than did the artificial corundum, although the expansion of china clay is generally lower than that of alumina. It has been noted in other tests that a reaction appears to take place between alumina and clay resulting in an expansion, which seems to be verified by these observations; the cause has not yet been determined. The approximate thermal expansions of the specimens burned to cone 16, from room temperature to 990° C., are as follows:

Material	Linear expansion
	Per cent.
Clay-bonded alumina	0.84
Artificial corundum	.79
Cyanite	.55
Silicon carbide	.53
Zirconium	.45

The per cent linear expansion, from room temperature to 990° C., varies from 0.51 to 0.62 for the English and domestic ball clays and from 0.46 to 0.66 for the foreign and domestic kaolins.

The three brands of silica brick tested showed approximately the same expansion, ranging from 1.10 to 1.20 per cent at 1,000° C. The per cent expansion of the fire brick observed varied (between room temperature and approximately 990° C.) from 0.46 to 0.76, and the detail results bring out many points of interest. For example, specimens taken from two brands made by the same manufacturer and supposedly of the same clays show a difference of 32 per cent in their thermal expansions at 985° C. It was also found that the differential expansion between two brands may be comparatively small for one temperature range but sufficiently large in another range to cause serious difficulties if they were interchanged in the same installation or if the proper division was not made in so far as construction is concerned. For example, the difference in expansion between brands D and H, and A and H was as follows:

Difference in linear thermal expansion in per cent		Temperature range from room temperature to—
A–H	D–H	
		° C.
40	28	490
67	60	590
20	26	990

DEFORMATION BEHAVIOR OF THE SYSTEM ANORTHITE-MULLITE-SILICA-MAGNETITE

The Columbus Branch of the Bureau of Standards in cooperation with a special refractory committee of the American Society of Mechanical Engineers and the fuel division of the Bureau of Mines is investigating slagging as a cause of failure in boiler refractories. It appeared from a petrographic study of refractories slagged in service and cooled slowly that the above crystal phases predominated where the temperature had been sufficiently high to cause serious slagging difficulty. An investigation was, therefore, undertaken to study the deformation behavior of various mixtures falling within the composition tetrahedron of which the above phases were the apices.

The various compositions were mixed up with dextrine water and molded into "cones" 1 inch long with a base of three-sixteenths inch. These were placed at a definite angle in a fire-clay plaque and their deformation studied in a platinum-wound alundum cup furnace as the temperature was raised 10° C. per minute. The atmosphere was controlled by the introduction of the gas desired. Air was used to produce oxidizing conditions, nitrogen to produce neutral conditions, and a mixture of nitrogen and carbon monoxide to produce reducing conditions.

A large portion of the composition tetrahedron was covered at 10 per cent intervals and the region of the low melting area covered at 5 per cent intervals. All results checked within ±10° C. Results to date indicate that under oxidizing conditions the eutectic area has for its center the composition:

10 per cent magnetite,
41 per cent anorthite,
49 per cent silica,
0 per cent mullite,

or converted into the oxides:

10 per cent Fe_3O_4,
8 per cent CaO,
15 per cent Al_2O_3,
67 per cent SiO_2.

This composition deformed below 1,300° C. The 1,400° C. contour plane has also been determined, as this is approximately the temperature reached in boiler practice. This is a lenticular zone occupying approximately one-fourth of the entire volume of the tetrahedron. Deformation behavior under neutral conditions proved to be identical with those obtained under oxidizing conditions.

The composition of the refractories ordinarily used in boiler furnaces fall near the mullite-silica edge of the tetrahedron, while the composition of a slag

usually falls within the tetrahedron near the anorthite-magnetite edge. A line drawn from a slag composition to a refractory composition should show all mixtures of the two from the pure slag through the area where the slag is attacking the refractory to pure refractory. The relations of this line to the soft area in the tetrahedron should indicate the action of this slag on this refractory (from a thermo-chemical viewpoint only). The work is being continued in order to study the relations under reducing conditions.

INVESTIGATION OF FELDSPAR

In 1922 the bureau undertook an exhaustive investigation of the raw materials entering into the compositions of white-ware bodies and the effects of variations of the raw materials on the qualities of the finished product. The first work, on whiting, was reported in the December, 1922, issue of the Journal of the American Ceramic Society. The second study, on ball clays, is reported in Bureau of Standards Technologic Paper No. 227 and in the February, 1924, issue of the Journal of the American Ceramic Society. The third study, on flint, is reported in Bureau of Standards Technologic Paper No. 310. The studies on English china clay (Technical News Bulletin No. 113, September, 1926) and on feldspar are now in progress.

The first phase of the investigation of feldspar, namely, the study of the characteristic properties of typical commercial feldspars, is now nearing completion, and some tests have also been made on bodies in which these feldspars were used. The typical commercial feldspars, 19 in number, were obtained through the cooperation of the white wares division of the American Ceramic Society. There was one "soda spar" included in this number, and the balance are so-called "potash spars." The composition of the soda spar (A) and the range in composition from the spar lowest in K_2O content (B) to that highest in K_2O content (C) are given in the following table. These values are the average of two determinations in the case of feldspars A and B and of three determinations in the case of spar C.

Material	Composition		
	Spar A	Spar B	Spar C
	Per cent	*Per cent*	*Per cent*
SiO_2	67.6	73.5	65.1
Al_2O_3	19.8	15.2	19.3
Fe_2O_3	.22	.05	.10
TiO_2	0	0	0
CaO	.5	.7	.2
MgO	.2	.1	.1
K_2O	.9	4.4	13.1
Na_2O	10.0	5.7	2.0
Ignition loss	.6	.5	.3

Grain size, or fineness determinations, were made by the bureau and also by four cooperating laboratories on specimens from the same samples, but sieves of the same number were not used by all of the laboratories, although sieves Nos. 100 and 200 were used by the five laboratories and sieve No. 325 by three of the laboratories for 16 of the feldspars. Accordingly, the results were calculated to show residues on these sieves. The average on the No. 100 sieve varied from 2.1 per cent to 0.0 per cent, that portion passing the No. 100 sieve and retained on the No. 200 sieve varied (average values) from 7.4 to 0.3 per cent, and that portion passing the 200 sieve and retained on the No. 325 sieve (average of three determinations) varied from 11.4 to 2.8 per cent. Average variations in the determinations were as follows: Sieve No. 100, 0.4 per cent; sieve No. 200, 2.4 per cent; sieve No. 325, 7.8 per cent; and the average variation for total residue on No. 325 sieve (calculated) was 11.2 per cent. Separations were also made by the air-analysis method. For the finest feldspar it was found that 17.0 per cent of the material was more than 0.04 mm in diameter and 32.4 per cent was more than 0.02 mm in diameter. The greatest residue after the 0.04 mm separation was 34.1 per cent, but this spar did not show the highest residue (48.3 per cent) after the 0.02 mm separation, one other feldspar having a residue of 49.1 per cent and another of 52.1 per cent.

The softening ranges of the feldspars varied in almost direct proportion to the K_2O content. The soda spar showed marked evidence of softening at cone 4 (approximately 1,150° C.), the spar lowest in K_2O content showed about the same degree of softening at cone 7 (approximately 1,210° C.), and the highest K_2O spar had softened to an equal amount at cone 10 (approximately 1,260° C.). At cone 13 (approximately 1,350° C.) all of the feldspars had completely fused.

The true specific gravity of the 19 feldspars varied from 2.635, for the soda feldspar, to 2.572 for the spar highest in K_2O. Check determinations were made on all of the feldspars, and the average variation between the first and the check determination was 0.002. The minimum was 0.000 and the maximum 0.005.

The results obtained to date indicate that the variations in feldspar composition and fineness of grind do not have a very marked effect on the translucency, porosity, and volume shrinkage of the white-ware bodies fired to various temperatures. They do indicate that the rate of heating and cooling may have an appreciable effect on the mechanical strength. However, it is felt that these results should be checked before any detailed conclusions are given.

COPPER ROOFING INVESTIGATION

In cooperation with the Copper and Brass Research Association the bureau is conducting a research on sheet-copper roofing covering the strength of soldered seams, the strength of corrugated sheets, temperature effects, and similar problems.

The type and size of seams and the amount of solder used are based, at present, on individual opinions or local practice, since there is a lack of numerical data. A series of tests recently completed was planned to remedy these conditions. Comparative tensile tests were made on lap and single lock seams, as these types are in most common use for flat seam roofing and gutters. The factors taken into consideration were the direction of rolling and thickness of the sheet, the kind of flux, and the manner of pretinning the edges of the sheets to be joined. Four sizes of lap seams were included and one size of lock seam with varying amounts of solder. The workmanship correspond with first-class commercial practice but with no laboratory refinements of any sort.

Although the data have not yet been entirely worked up, the following general conclusions are evident:

1. Lap seams wider than one-fourth inch are stronger than single lock seams which are tinned by hand on the job according to the usual practice.

2. If the edges of the sheets to be joined are pretinned by dipping in tin or solder, single lock seams are as strong as or stronger than the sheets for all thicknesses tested.

3. Lap seams three-fourths inch wide are as strong as or stronger than the sheets for all thicknesses tested.

4. A relatively great increase in the amount of solder gives a slight increase in strength to single-lap seams tinned by hand.

5. Direction of rolling of the sheets and the type of flux used have practically no effect on the seam strength.

Under conditions of severe corrosion copper for corrugated roofing or siding appears to offer advantages over the more usual materials. Since corrugated copper sheets have not been used for these purposes, loading tests have been made to determine the proper form of corrugation, thickness of material, and purlin spacing required under the roof loads which may occur. Sheets of several thicknesses and of different corrugations were tested under uniform loading over three different spans. Because of the peculiar elastic properties of copper the deflection of a sheet under load will continue to increase with time at a decreasing rate. Also, when the load is removed, there will be a residual deflection which will decrease with time approaching a constant value. In order to evaluate these time effects, each sheet under test was subjected to three periods under load alternating with three periods without load, and daily measurements of the deflection were made. The results are not yet available.

Flat-seam construction is used on roofs of very slight pitch and in box gutters. Temperature variations may cause buckling or under extreme conditions tearing or cracking of the sheets and also of the seams. The dimensions of the sheets, the character of the seams, and the type of attachment to the sheathing may have an important bearing on the magnitude of the temperature effects. The size of sheet is also economically important, since it determines the total length of seams required. Tests are in progress in which the effects of temperature variations are being studied on full-size roof panels varying in construction.

As a preliminary to these tests, continuous temperature records of a copper roof on a large Government building in Washington were obtained. The maximum difference in temperature between the copper roof and the free air was found to be about 15.6° C. (60° F.), indicating a maximum roof temperature of 71.1 or 76.7° C. (160 or 170° F.) under extreme conditions. The maximum measured in 1926 was 63.9° C. (147° F.). The minimum (at night) was never more than 8.3° C. (15° F.) below the air temperature. In January, 1926, a minimum of —12.2° C. (+10° F.) was recorded. The average daily range during May, 1926, was 37.2° C. (67° F.).

The laboratory tests are made in a large chamber, thermally insulated, which is capable of receiving a roof section 10 by 7 feet in size. Temperatures from 0 to 82.2° C. (32 to 180° F.) are obtainable, and the distribution of temperature over the test specimen may be varied by baffle walls. Temperatures of the copper are measured by thermocouples, deformations of the sheathing by dial gauges, and deformations of the copper at selected points by a specially designed 2-inch strain gauge reading to ten-thousandths of an inch.

MISUSE AND MISREPRESENTATION OF REPORT ON ARTIFICIAL DAYLIGHT LAMP

For some months past the American promoters of an "artificial daylight lamp" said to be the "invention of a Frenchman named Gamain," have been making public reference to a test of this lamp made by the Bureau of Standards.

Unwarranted claims made for this lamp are coupled with references to tests by this bureau in such a way as to suggest the bureau's indorsement. This misuse of a Bureau of Standards' report may mislead those not technically acquainted with the history of the development of "artificial daylighting equipment" and so work an injustice to a legitimate business in the manufacture of such apparatus which has been established in this country for a number of years.

The following are the facts in this case:

1. The test report to which reference has been made (B. S. Test No. 46959) was issued on condition that it was not to be used for advertising purposes.

2. The report has been very inaccurately quoted in numerous newspaper and magazine articles.

3. There is absolutely nothing in the report to suggest that the "Gamain" lamp is in any way superior to artificial daylighting equipment of American invention and American manufacture, which has been available on the American market for many years.

As a matter of fact, the Bureau of Standards considers the design of the "Gamain" lamp inferior to the above-mentioned American apparatus.

ADHERENCE TO SIMPLIFIED PRACTICE RECOMMENDATIONS

In 19 different lines the average adherence to the Simplified Practice Recommendations is 79 per cent. In other words, an average of practically four-fifths of last year's output in these lines conformed to the sizes, dimensions, etc., in the simplification programs adopted through joint conference of representative manufacturers, distributers, and consumers concerned. Details are as follows:

Commodity	Adherence
	Per cent
Beds, mattresses, and springs	51
Sand-lime brick	62
Hospital beds	69
Asphalt (grades)	74
Paving bricks	74
Face brick	74
Milk bottles and caps	75
Lumber	80
Shotgun shells	81
Hollow building tile	84
Sheet steel (jobbers)	53
Brass sink traps	75
Hot-water storage tanks	82
Steel barrels and drums	84
Steel reinforcing bars	85
Woven wire fence	97
Eaves trough and conductor pipe	97
Metal lath	99
Range boilers	99
Average	79

The above figures are taken from the resurveys made by the standing committees responsible for the success of the simplification programs in their respective industries. In nearly every case above cited the resurvey covered 80 per cent or more of the output of the entire industry. Had it been possible to obtain statistics from all the plants producing these commodities, the percentages of adherence might have run even higher.

This degree of support accorded simplified practice demonstrates that the firms cooperating in simplification have found it pays. Such adherence to simplification programs would not occur if it did not produce a real return. In every one of these cases each industry, prior to simplification, thought it necessary to have a multiplicity of sizes, dimensions, grades, etc. Now they know it is not, for most of them are doing a greater volume of busines than ever before. To the industries which have not yet applied simplification, its success in the above fields is a constant challenge.

STANDARD INVOICE FORM

In connection with their program for the year, the National Association of Purchasing Agents (Inc.) will concentrate on a "drive" to accelerate the adoption of the National Standard Invoice Form. The Committee on National Standard Invoice Form will consist of one district chairman for each district, the national secretary acting as chairman of this national committee. Each district chairman will supervise the work of the various local committees in his district so as to tie them together into a single working unit, thus securing for all the benefits of the good ideas of each association. Duplication will thus be avoided, and the method of securing adoption of the National Standard Invoice Form will be standardized. The editors of association magazines and bulletins, the invoice chairmen of affiliated associations, and others have been asked to assist in the drive by running articles and advertisements in their publications.

More than 80 nationally known trade associations have already indorsed the form. Thousands of corporations and a majority of the large railroad systems throughout the country are demanding its use. Following this, the Comptroller General of the United States has requested all Government vendors to bill on the National Standard Invoice Form.

Some of the principal advantages of a standard invoice form are—eliminates misunderstandings and inconveniences; expedites shipments and the settlements of accounts; saves money by reducing clerical personnel; saves paper by cutting from standard-size stock without waste; saves correspondence by including all necessary information on the forms themselves; saves time in filing, finding, and handling while being checked; and saves filing space through uniformity of size, etc.

REMOVAL OF MERCUROCHROME STAINS FROM CLOTHING

The dry-cleaning industry, through its research associateship at the bureau, endeavors to familiarize itself with the cleaning processes necessary to remove materials that are used in the household and are accidentally spilled on clothing. Some difficulty has been experienced in removing mercurochrome, an antiseptic now being used in many households instead of iodine. This product contains

mercury in combination with an eosine type of dyestuff.

It has been found that fresh mercurochrome stains may be removed from silk material by first applying benzaldehyde, allowing it to stand for a few minutes, and repeating the application, then applying a 25 per cent solution of hydrochloric acid. It is well to follow this treatment by sponging with alcohol and then freely with water.

Some cleaners have found that an application of glacial acetic acid to the fresh stain is fairly effective. When only partially effective. this must later be treated with ether.

The dry cleaners must be particularly careful that this stain be removed when it is fresh, because mercury in solution when encountering sulphur becomes mercuric sulphide, which is black in color, and this black stain is insoluble and can not be removed from the fabric. Sulphur may be encountered in the dry-cleaning plant either from traces contained in some of the cleaning solvents or from free sulphur in the air resulting from materials used in the cleaning of hats or in the form of gas from the boiler, etc.

TESTS FOR DETERIORATION OF STORED TABLE LINEN

Several years ago the Emergency Fleet Corporation had a large amount of linen material which developed weak places. On account of other causes it was impossible to determine at that time just how much deterioration was due to storage, although it was evident that this was a fairly large factor. Arrangements were made with the bureau to test the number of samples of completely bleached linen and a sample of unbleached linen to determine if possible what the effect would be when these materials were subjected to ordinary storage conditions. Tests were made at intervals of three months. It was noted very early in this series of tests that a marked variation in the results was being obtained. At the end of one year it was found that some of the samples had gained while other samples had lost some of the original strength. The remainder of the material was then laid out to provide a large number of representative samples in order to determine the variation of the material due to constructional features. The results showed a maximum variation in some cases of 15 per cent. The collection of the data resulted in the conclusion that no marked deterioration resulted from storing any of the linen samples for a period of one year.

COOPERATIVE FUEL RESEARCH TO DATE

(Paper presented by Dr. H. C. Dickinson at meeting of American Petroleum Institute, Tulsa, Okla., December 8, 1926)

You will recall that the cooperative fuel research project was begun in 1922 when the petroleum and automotive industries through the American Petroleum Institute and the National Automobile Chamber of Commerce provided a joint fund to be administered by the Society of Automotive Engineers for the prosecution of a research program at the Bureau of Standards. This program was placed under the general supervision of a joint steering committee which has met frequently, authorized the general lines of work, and passed upon the results before they were made public.

Under this joint arrangement the first project undertaken was to determine what was the best gasoline as regards volatility, considered on a broad economic basis. In other words, "What grade of gasoline would afford the maximum number of car-miles of transportation per barrel of crude oil used in its production?" This question obviously could not be answered in the laboratory alone. It did not suffice to know how much more efficiently an ideal engine in the laboratory could be run on one fuel than another; but it was necessary to know how much more of one kind of fuel than of another the average driver would use on the road. This difference multiplied by the total number of cars in the country might be expected to give the difference in national consumption of the two fuels. This figure, together with an estimate of the

difference in cost of the two fuels, would answer the question.

The problem was attacked from two different angles. First, four test fuels, designated A, B, C, and D, covering the practical range of volatilities, were specified for experimental purposes and made up in quantity by two different refineries, one in the Middle West and one in the East. For the first angle of attack four types of passenger cars were selected, these four types representing about 75 per cent of the total number of cars in service at that time. One used car of each type, which had been run from one to two years, was secured for a test program at the Bureau of Standards. These cars were put through a most exhaustive series of tests, under road conditions, for average fuel consumption with each of the four different fuels. The details of this program were carefully considered by the steering committee as well as by the Bureau of Standards staff, to be sure that the results would be truly typical of average driving conditions. The program consisted of one series of tests in summer with all four cars and another complete series in winter with two of the cars.

For the second angle of attack, which was put through mainly by the Research Department of the Society of Automotive Engineers, some 10 automobile manufacturing companies were enlisted in two road-test programs, one run in summer and another in winter. Each company selected a group of from 4 to 12 cars driven in regular service by members of its staff and purchased enough of the four test fuels to supply the group of selected cars for at least four weeks. Each of these cars was supplied with one of the experimental fuels for one week, another for the second week, and so on, according to a carefully prearranged program designed to average out weather conditions and individual differences. Thus, each series of tests for each company lasted four weeks. The total number of car-weeks was about 250 for the summer series. The following winter this entire program was repeated under cold-weather conditions, the group of companies not being quite the same for the two series.

Thus, there were two distinct projects, each covering both a winter and a summer schedule. One of these was run by the Bureau of Standards under road conditions, but with laboratory precision, the other by 10 or more individual companies, involving about 150 cars, which were driven by their owners in ordinary service. In no case did the driver of the car know which one of the four test fuels was being used at any particular time.

When the results of all these four independent series of tests had been collected, the following conclusions were reached:

1. Within the range covered by the test fuels the number of ton-miles per gallon is independent of the fuel volatility. Consequently the heaviest fuel was the most economical. (Federal specifications for motor gasoline were modified on the strength of this result.)

2. Gasoline consumption is somewhat greater in winter than in summer.

3. Dilution of crank-case oil is consistently greater the heavier or less volatile the fuel.

4. Dilution of crank-case oil is much greater in cold weather than in warm.

5. Small apparent differences in fuel volatility have a large effect on engine starting.

6. Starting performance of the fuel is the quality most readily noted by the driver.

From this survey it was concluded that economy dictates the use of as heavy a fuel as possible, but that a practical limit in this direction is set by the dilution of crank-case oil and the difficulty of starting.

The committee then decided to make a study of crank-case oil dilution. Data were already at hand from the analysis of samples secured in the tests mentioned above.

A carefully arranged program on this subject, covering nearly two years of work at the Bureau of Standards, led to the following general conclusions:

1. Dilution depends upon the temperature of the engine cylinder walls and upon the volatility of the gasoline, the 90 per cent point on the American Society for Testing Materials distillation curve being taken as an index of volatility.

2. Dilution increases with richness of mixture.

3. Dilution decreases with higher temperature in the crank case and particularly when the crank case is ventilated.

4. Dilution does not increase indefinitely but tends to reach a definite percentage depending upon average operating conditions.

5. This equilibrium dilution is not much affected by air temperature, piston and ring fit, or oil viscosity.

Thus, to reduce dilution—

1. Operate with high cylinder-wall temperature.

2. Reduce the time required to reach normal operating temperature.

3. Always use as lean mixtures as practicable.

4. Operate with high oil temperature.

5. Ventilate the crank case.

As the bureau's work on fuel consumption was supplemented by the road-service tests mentioned above, likewise the laboratory results on dilution were supplemented by the analysis of some 600 samples of used crank-case oils. These samples were collected according to a carefully prepared schedule from typical makes of cars distributed throughout the country. The collection of samples was undertaken by the Research Department of the Society of Automotive Engineers, and the results have been summarized and published in its journal, where other papers will be found covering the results outlined above.

In the course of this work there were developed two very satisfactory methods for measuring crank-case oil dilution, one of which is under consideration by the American Society for Testing Materials for a tentative standard and is now very widely used.

A distillation test for gasolines has been devised, which duplicates the conditions in an engine manifold. This method is being studied by several refineries and promises to be of considerable value.

The third major project, that of engine starting as affected by fuel characteristics, has been under way for over a year and is the subject of a report to be presented later in this session.

What has been said presents briefly the most important tangible results of this joint research. Its underlying object is to furnish both the petroleum and the automotive industries with the technical information needed to maintain the best practicable adjustment of the fuel to the engine and the engine to the fuel.

These two industries have contributed jointly to date on a 50–50 basis some $45,000, of which about $35,000 has been expended. More than $40,000 has been contributed by the Government.

While the tangible results seem to be worth much more than their cost, some of the intangible results may be even more important. When this work was initiated in 1921, the two industries in question did not speak the same language. Each was inclined to place full responsibility on the other, and the first attempts at bringing representatives of the two industries together around a table for technical discussion led to endless debate and frequent recrimination; but there has been a decided change in the attitude of each industry toward the other.

Conferences between petroleum and automotive engineers concerning the joint-research program and open discussion of its results in the annual meetings of the American Petroleum Institute and the Society of Automotive Engineers doubtless have been an important factor in bringing about a better mutual understanding.

Moreover, conditions with respect to motor fuels available and fuel research have changed radically. A few years ago, so far as we know, there was scarcely a research laboratory in the petroleum industry engaged in any systematic study of the qualities of gasoline in relation to engine performance. Gaso-

line was then aptly defined by a prominent engineer as the cheapest hydrocarbon product which could be made to burn in an automobile engine, or words to that effect. To-day, on the other hand, many, if not most, of the large producers of motor fuels are doing intensive work along this line. Fuels are being produced with direct regard to how they will perform in winter, in summer, as to knock value, and as to crankcase dilution. In fact, the fuel engineers seem to have surpassed the motor-car engineers in an understanding of what the engine needs in the way of fuel.

This radical change which has taken place in the attitude of these two great industries toward each other and toward research on their common problems can not be credited entirely to the cooperative research program, though there is little doubt that this program has had an important influence directly and indirectly in bringing about the present very satisfactory relation of the two industries toward the adaptation of fuels to existing engines and engines to available fuels for the benefit of civilization.

A PORTABLE RADIO DIRECTION FINDER FOR 90 TO 7,700 KILOCYCLES

The bureau has just issued a paper which describes the development of a portable radio direction finder with but two controls—one for tuning and one for balancing. This direction finder operates over the frequency band from 90 to 7,700 kilocycles (3,300 to 39 meters). The direction finder is of the simple rotating coil type. The receiving set is of the superheterodyne type, with the controls reduced to one by the use of a cam-operated condenser. The wide frequency range is made possible by a set of seven interchangeable plug-in direction finder coils, each with a corresponding heterodyne generator coil and cam for operating the auxiliary tuning condenser.

This paper, Bureau of Standards Scientific Paper No. 536, A Portable Radio Direction Finder for 90 to 7,700 Kilocycles, by F. W. Dunmore, is obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 10 cents per copy.

RESISTANCE OF CONDUCTORS OF VARIOUS TYPES AND SIZES AS WINDINGS OF SINGLE-LAYER COILS AT 150 TO 6,000 KILOCYCLES

A paper just issued by the bureau gives resistance data in the form of curves for coils wound with various sizes of solid wire, litz wire, and copper tubing. The purpose of the measurements was to obtain data which would assist in the selection of the conductors of lowest resistance for the coils of a standard frequency meter or wave meter. The measurements were made by the resistance-variation method. The curves for the various sizes of wires are directly comparable because the coils have approximately the same inductance, owing to the fact that they were wound in succession on the same form. The curves given are of value in selecting the size of wire of least resistance for a given frequency within the range from 150 to 6,000 kilocycles. For coils of this type at frequencies below 1,500 kilocycles the superiority of litz wire of a large number of strands is shown, while above that limit a coil of large-size solid copper wire or copper tubing is preferable.

This paper is known as Bureau of Standards Technologic Paper No. 330, "Resistance of Conductors of Various Types and Sizes as Windings of Single-Layer Coils at 150 to 6,000 Kilocycles," by E. L. Hall. Copies may be obtained for 5 cents each from the Superintendent of Documents, Government Printing Office, Washington, D. C.

NEW PUBLICATIONS

Additions to Supplementary List of Publications of the Bureau of Standards (beginning July 1, 1926)

Scientific Paper [1]

S536. A portable radio direction finder for 90 to 7,700 kilocycles; F. W. Dunmore. Price, 10 cents.

Technologic Papers [1]

T325. Recent developments in lamp life-testing equipment and methods; J. F. Skogland and R. P. Teele, jr. Price, 15 cents.

T327. Compressive strength of column web plates and wide web columns; Robert S. Johnston. Price, 20 cents.

T328. Tests of large columns with H-shaped sections; L. B. Tuckerman and A. H. Stang. Price, 40 cents.

T329. Research on the production of currency paper in the Bureau of Standards experimental paper mill; Merle B. Shaw and George W. Bicking. Price, 10 cents.

T330. Resistance of conductors of various types and sizes as windings of single-layer coils at 150 to 6,000 kilocycles; E. L. Hall. Price, 5 cents.

Circulars [1]

C8 (4th ed.). Testing of thermometers. Price, 10 cents.

C24 supplement. Supplementary list of publications of the Bureau of Standards (July 1, 1925, to June 30, 1926). Free on application to bureau.

C25 supplement (July 1, 1926). Standard samples issued or in preparation. Free on application to bureau.

C130 (2d ed.). United States Government master specification for soap, cake, grit. Price, 5 cets.

C265 (2d ed.). United States Government master specification for denim, indigo blue (shrunk). Price, 5 cents.

C299 (2d ed.). United States Government master specification for brick, fire-clay. Price, 5 cents.

C312. United States Government master specification for matting, rubber, for use around electrical apparatus or circuits not exceeding 3,000 volts to ground. Price, 5 cents.

C313. United States Government master specification for towels, huck (with woven name). Price, 5 cents.

C315. United States Government master specification for soda, caustic (lye), (for cleaning purposes). Price, 5 cents.

Simplified Practice Recommendations [1]

(Elimination of Waste)

R4 (1st revision). Asphalt. Price, 5 cents.

R46. Tissue paper. Price, 5 cents.

R54. Sterling silver flatware. Price, 5 cents.

RXIII. A primer of simplified practice. Price, 15 cents.

Technical News Bulletin [1]

TNB117. Technical News Bulletin, January, 1927.

OUTSIDE PUBLICATIONS [2]

Surface sizing of paper with glue. G. K. Hamill, V. H. Gottschalk, G. W. Bicking; Paper Trade Journal, Vol. 83, No. 23, p. 39; December 2, 1926.

Paper research of the United States Bureau of Standards during 1926. B. W. Scribner; Paper Trade Journal, Vol. 83, No. 24, p. 45; December 9, 1926.

Methods of socketing fiber rope for tensile strength tests (II). H. L. Whittemore and C. T. Ervin; Cord Age, Vol. 9, No. 6, p. 12; December, 1926.

Some properties of lime-gypsum mixes. L. E. Smith; Rock Products, p. 39; November 27, 1926.

Rough turning tests on alloy steels. H. J. French and T. G. Digges (Abstract of previous paper before A. S. M. E.); American Machinist, Vol. 65, p. 957; 1926.

Metallurgical research work at the Bureau of Standards. H. W. Gillett (Reprinted from Forging-Stamping-

[1] Send orders for publications under this heading, with remittance, only to Superintendent of Documents, Government Printing Office, Washington, D. C. Subscription to TECHNICAL NEWS BULLETIN, 25 cents per year (United States); 40 cents (foreign).

[2] "Outside publications" are not for distribution or sale.

Heat Treating); Blast Furnace and Steel Plant, Vol. 14, p. 515; 1926.

The work of the Bureau of Standards on dyes. W. D. Appel; Industrial and Engineering Chemistry, Vol. 18, p. 1341; 1926.

Viscosity and temperature changes. W. H. Herschel; Oil and Gas Journal, Vol. 25, No. 28, p. 146; December 2, 1926.

Applications of radio in air navigation. J. H. Dellinger; Engineers and Engineering, Vol. 43, p. 301, November 15, 1926, and Mechanical Engineering, Vol. 49, p. 29; January, 1927.

The International Union of Scientific Radio Telegraphy. J. H. Dellinger; Science, Vol. 64, p. 638; December 31, 1926.

Dental research. Wilmer Souder; United States Daily, Vol. 1, No. 242, p. 16; December 15, 1926.

Blood pressure gauges. H. B. Hendrickson; United States Daily, Vol. 1, No. 243, p. 10; December 16, 1926.

Clinical thermometers. Johanna Busse; United States Daily, Vol. 1, No. 248, p. 16; December 22, 1926.

Blood testing. L. V. Judson; United States Daily, Vol. 1, No. 250, p. 16; December 24, 1926.

Blood testing. E. L. Peffer; United States Daily, Vol. 1, No. 252, p. 16; December 28, 1926.

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